

Application No. 10/080,638
Amendment

Customer No. 01933

Listing of Claims:

Claims 1-86 (Canceled).

87. (Currently Amended) ~~The~~ An optical element producing method ~~described in claim 86, of producing an optical element with a microscopic predetermined pattern thereon, said method comprising:~~

5 irradiating an electron beam onto a layer of a base material; and

~~wherein the predetermined pattern is formed by controlling an energy amount of the electron beam exposed on~~ irradiated onto the layer of the base material to draw the predetermined pattern;

10 wherein the pattern-drawn layer comprises a curved surface on which the predetermined pattern is drawn.

88. (Currently Amended) The optical element producing method described in claim 87, wherein a depth ~~formed~~ at a point on the predetermined pattern is ~~varied~~ set by controlling the energy amount of the electron beam ~~exposed~~ irradiated to the layer at the point.

89. (Currently Amended) The optical element producing method described in claim 88, wherein the energy amount of the

Application No. 10/080,638
Amendment

Customer No. 01933

electron beam ~~at the point~~ is controlled within a depth of focus
~~at a focus position~~ of the electron beam.

90. (Currently Amended) ~~The~~ An optical element producing
method ~~described in claim 86,~~ of producing an optical element
with a microscopic predetermined pattern thereon, said method
comprising:

5 irradiating an electron beam onto a layer of a base material
to draw the predetermined pattern; and

~~wherein the focus changing a position of a depth of focus of~~
the electron beam ~~on the base material is adjusted~~ by controlling
an electron lens, ~~so as to shift a heightwise~~ adjust a drawing
10 position of the focus position within a depth of focus electron
beam on the base material;

wherein the pattern-drawn layer comprises a curved surface
on which the predetermined pattern is drawn.

Claim 91 (Canceled).

92. (Currently Amended) ~~The~~ An optical element producing
method ~~described in claim 86,~~ further of producing an optical
element with a microscopic predetermined pattern thereon, said
method comprising the steps of:

Application No. 10/080,638
Amendment

Customer No. 01933

- 5 irradiating an electron beam onto a layer of a base material
to draw the predetermined pattern;
- forming a molding die based on ~~the basis of~~ the base
material ~~on which~~ with the predetermined pattern has ~~been~~ drawn
thereon; [[,]] and
- 10 producing an optical element by conducting an injection
molding for process with the molding die;
- wherein the pattern-drawn layer comprises a curved surface
on which the predetermined pattern is drawn.
93. (Currently Amended) ~~The~~ An optical element producing
method ~~described in claim 86, further of producing an optical~~
element with a microscopic predetermined pattern thereon, said
method comprising the steps of:
- 5 irradiating an electron beam onto a layer of a base material
to draw the predetermined pattern;
- developing the base material irradiated with the electron
beam; [[,]] and
- conducting an electroforming process on the developed base
10 material ~~so as~~ to form a molding die;
- wherein the pattern-drawn layer comprises a curved surface
on which the predetermined pattern is drawn.

Application No. 10/080,638
Amendment

Customer No. 01933

94. (Currently Amended) The optical element producing method described in claim 93, ~~wherein the base material is subjected to~~ further comprising conducting an etching process on the base material before the electroforming process.

95. (Currently Amended) ~~The~~ An optical element producing method ~~described in claim 86, wherein the drawing step is conducted for a first base material and a second base material respectively, and the optical element producing of producing an~~ optical element with a microscopic predetermined pattern thereon,
5 said method further comprising the steps of:

irradiating an electron beam onto a layer of a first base material to draw a first pattern thereon;

irradiating an electron beam onto a layer of a second base
10 material to draw a second pattern thereon;

forming a first molding die and a second molding die respectively based on the first and second base materials;

assembling a mold by arranging the first and second molding dies to be opposite to each other; and

15 conducting an injection molding for process with the mold so as to form an the optical element having a configuration corresponding such that the predetermined pattern corresponds to the first and second patterns drawn on the the first and second base materials.

Application No. 10/080,638
Amendment

Customer No. 01933

96. (Currently Amended) The optical element producing method described in claim 95, wherein one of the first pattern and the second pattern comprises a polarized light splitting structure ~~is drawn on one of the first and second base materials~~ and the other of the first pattern and the second pattern comprises a diffractive grating structure ~~is drawn on the other base material~~.

97. (Currently Amended) The optical element producing method described in claim 95, wherein one of the first pattern and the second pattern comprises a birefringence phase structure ~~is drawn on one of the first and second base materials~~ and the other of the first pattern and the second pattern comprises a diffractive grating structure ~~is drawn on the other base material~~.

Claim 98 (Canceled).

99. (Currently Amended) The A pattern drawing method described in claim 98, of forming a predetermined pattern on a layer of a base material, said method comprising:
irradiating an electron beam onto the pattern-drawn layer;
and

Application No. 10/080,638
Amendment

Customer No. 01933

~~wherein the predetermined pattern is formed by controlling an energy amount of the electron beam exposed on irradiated onto the layer of the base material to draw the predetermined pattern;~~

10 wherein the layer comprises a curved surface on which the predetermined pattern is drawn.

100. (Currently Amended) The pattern drawing method described in claim 99, wherein the energy amount of the electron beam is controlled in accordance with a predetermined dose amount.

101. (Currently Amended) The pattern drawing method described in claim 99, wherein a depth ~~formed~~ at a point on the predetermined pattern is ~~varied~~ set by controlling the energy amount of the electron beam ~~exposed~~ irradiated to the layer at the point.

102. (Currently Amended) The pattern drawing method described in claim 101, wherein the energy amount of the electron beam ~~exposed at the point~~ is controlled within a depth of focus ~~at a focus position~~ of the electron beam.

Application No. 10/080,638
Amendment

Customer No. 01933

103. (Currently Amended) The A pattern drawing method
~~described in claim 98, of forming a predetermined pattern on a~~
layer of a base material, said method comprising:

irradiating an electron beam onto the pattern-drawn layer;

5 and

~~wherein the step of drawing is conducted by changing a focus~~
drawing position of the electron beam relatively on to the base
material to draw the predetermined pattern;

wherein the layer comprises a curved surface on which the
10 predetermined pattern is drawn.

104. (Currently Amended) The pattern drawing method
described in claim 103, wherein the ~~focus~~ drawing position of the
electron beam on the base material is changed by adjusting ~~the a~~
depth of focus position of the electron beam.

105. (Currently Amended) The pattern drawing method
described in claim 104, wherein the depth of focus position of
the electron beam ~~on the base material~~ is adjusted by controlling
an electron lens of the electron beam so as to ~~shift a heightwise~~
5 ~~position of~~ adjust the ~~focus~~ drawing position within a depth of
focus.

Application No. 10/080,638
Amendment

Customer No. 01933

106. (Currently Amended) The pattern drawing method described in claim 105, wherein the ~~focus position of the electron beam lens~~ is ~~adjusted~~ controlled by controlling a value of an electric current for the electron lens.

107. (Currently Amended) The pattern drawing method described in claim 103, wherein the ~~focus~~ drawing position of the electron beam is changed by ~~conducting a positional adjustment while~~ moving the base material.

108. (Currently Amended) The pattern drawing method described in claim 103, wherein the ~~focus~~ drawing position of the electron beam is changed by at least one of adjusting ~~the~~ a depth of focus position of the electron beam ~~or by conducting a positional adjustment while~~ and moving the base material.

109. (Currently Amended) The pattern drawing method described in claim 108, further comprising ~~a calculating step of~~ calculating at least a ~~heightwise position~~ height of a ~~pattern-~~ drawn a pattern-drawing position on the base material at which the pattern is to be drawn.

Claim 110 (Canceled).

Application No. 10/080,638
Amendment

Customer No. 01933

111. (Currently Amended) The pattern drawing method described in claim ~~110~~ 109, wherein the predetermined pattern ~~drawing step comprises a step of~~ is drawn by drawing a pattern ~~for at least on~~ a first field of a unit space in a three-
5 dimensional reference coordinate system based on ~~the basis of~~ the calculated ~~pattern-drawn~~ pattern-drawing position, and ~~a step of~~ then drawing a pattern for at least a second ~~field~~ field while ~~conducting again the calculating a pattern drawing position in~~ the at least the second field at which the pattern is to be
10 drawn. ~~step and the position adjusting step after completing the pattern drawing step for the first field.~~

112. (Currently Amended) The pattern drawing method described in claim 109, further comprising ~~a thickness distribution measuring step of~~ measuring the a thickness distribution of the base material ~~beforehand~~ before calculating the height of the pattern-drawing position.

113. (Currently Amended) The pattern drawing method described in claim 112, wherein the ~~calculation step calculates at least the heightwise position~~ height of the ~~pattern-drawn~~ pattern-drawing position is calculated based on ~~the basis of~~ the thickness distribution of the base material.

Application No. 10/080,638
Amendment

Customer No. 01933

114. (Currently Amended) The pattern drawing method described in claim 112, ~~further comprising a thickness distribution measuring step of measuring wherein~~ the thickness distribution of the base material is measured while irradiating the electron beam.

115. (Currently Amended) The pattern drawing method described in claim 112, further comprising ~~the steps of:~~
~~a reference point measuring step of measuring positions of a~~
plurality of reference points while irradiating the electron
5 beam; [[,]] and

~~a correcting step of correcting the measurement of the~~
thickness distribution based on ~~the basis of~~ the positions of the
plurality of reference points, while irradiating the electron
beam.

116. (Currently Amended) The pattern drawing method described in claim 115, wherein measuring the thickness distribution ~~measuring step includes a step of comprises:~~

calculating a first three-dimensional reference coordinate
5 system in the base material based on ~~the basis of~~ the plurality
of reference points; ~~measured beforehand on the base material and~~
~~a step of~~

Application No. 10/080,638
Amendment

Customer No. 01933

calculating at least a first heightwise height position of
~~the pattern-drawn position~~ in the first reference coordinate
10 system; $[[,]]$ and ~~the~~

wherein correcting step includes a step of the measurement
of the thickness distribution comprises:

calculating a second three-dimensional reference coordinate
system in the base material based on ~~the basis of~~ a plurality of
15 reference points measured when the base material is placed on a
pattern drawing stage; and ~~a step of~~

calculating a second heightwise height position in the
second reference coordinate system corresponding to the first
heightwise height position as a ~~heightwise position height~~ of the
20 ~~electron beam at the pattern-drawn~~ pattern-drawing position.

117. (Currently Amended) The pattern drawing method
described in claim 115, wherein ~~the reference point measuring~~
~~step includes a step of~~ the positions of the plurality of
reference points comprises:

5 irradiating a light beam to the base material from a
direction approximately substantially perpendicular to the
electron beam; ~~a step of~~

detecting a light intensity distribution based on the light
beam passing through the base material ~~on the basis of the light~~
10 ~~beam;~~ and ~~a step of~~

Application No. 10/080,638
Amendment

Customer No. 01933

calculating ~~the heightwise position~~ a height of the base material based on ~~the basis of~~ the light intensity distribution.

118. (Currently Amended) The pattern drawing method described in claim 115, wherein ~~the reference point~~ measuring ~~step includes steps of~~ the positions of the plurality of reference points comprises:

5 irradiating a first light beam to the base material from a direction crossing the electron beam to be reflected off a bottom portion of the base material; and

10 detecting a first light intensity distribution ~~reflecting based on the first light beam reflected from a flat the bottom~~ portion of the base material ~~on the basis of the first light beam; steps of~~

irradiating a second light beam different from the first light beam to the base material from a direction substantially perpendicular to the electron beam; and

15 detecting a second light intensity distribution based on the second light beam passing through the base material; ~~on the basis of the second light beam and steps of~~

20 calculating a ~~heightwise position~~ height of the a flat portion based on ~~the basis of~~ the first intensity distribution; and

Application No. 10/080,638
Amendment

Customer No. 01933

calculating a ~~heightwise position~~ height of a point on ~~a the~~
curved surface ~~portion projecting from the flat portion of the~~
base material based on the ~~basis of~~ the second intensity
distribution.

119. (Currently Amended) The pattern drawing method
described in claim 109, wherein the calculating ~~step includes a~~
~~step of the height of the pattern-drawing position comprises:~~

calculating a first three-dimensional reference coordinate
5 system in the base material based on the ~~basis of~~ a plurality of
reference points measured beforehand on the base material; ~~a~~
~~step of~~

calculating at least a first ~~heightwise~~ height position of
the ~~pattern-drawn position~~ in the first reference coordinate
10 system; ~~a step of~~

calculating a second three-dimensional reference coordinate
system in the base material based on the ~~basis of~~ a plurality of
reference points measured when the base material is placed on a
pattern drawing stage; ~~[[,]]~~ and ~~a step of~~

15 calculating a second ~~heightwise~~ height position in the
second reference coordinate system corresponding to the first
~~heightwise~~ height position as a ~~heightwise position at the~~
~~pattern-drawn~~ height of the pattern-drawing position of the
electron beam.

Application No. 10/080,638
Amendment

Customer No. 01933

120. (Currently Amended) The pattern drawing method described in claim 109, wherein the calculating step the height of the pattern-drawing position is carried out while irradiating the electron beam.

Claims 121-124 (Canceled).

125. (Currently Amended) ~~The A~~ pattern drawing method ~~described in claim 124, of forming a predetermined pattern on a layer of a base material, said method comprising:~~

irradiating an electron beam onto the pattern-drawn layer to
5 draw the predetermined pattern;

wherein the layer comprises a curved surface on which the
predetermined pattern is drawn;

wherein the predetermined pattern corresponds to a specific
pattern for an optical element; and

10 wherein the specific pattern comprises a diffractive grating
structure which is formed based on the basis of a predetermined
dose distribution for the electron beam corresponding to a
scanning position of the electron beam.

Application No. 10/080,638
Amendment

Customer No. 01933

126. (Currently Amended) The pattern drawing method described in claim 125, wherein ~~the characteristic~~ a contour of the dose distribution is defined beforehand.

127. (Currently Amended) The pattern drawing method described in claim 125, wherein ~~the characteristic of the dose distribution is one that is extracted in accordance with~~ based on an inclination angle of a slope on of the curved surface portion.

128. (Currently Amended) ~~The~~ A pattern drawing method described in claim 123, of forming a predetermined pattern on a layer of a base material, said method comprising:

irradiating an electron beam onto the pattern-drawn layer to
5 draw the predetermined pattern;

wherein the layer comprises a curved surface on which the predetermined pattern is drawn;

wherein the predetermined pattern corresponds to a specific pattern for an optical element; and

10 wherein the specific pattern includes comprises a pattern for reducing surface reflection reducing structure.

129. (Currently Amended) The pattern drawing method described in claim 128, wherein ~~when~~ the reflection reducing structure comprises concave and convex portions are formed for

Application No. 10/080,638
Amendment

Customer No. 01933

the pattern for reducing surface reflection, and a dose
5 distribution for the electron beam including a dose for a the
concave ~~or~~ and convex ~~portion~~ portions is calculated for a
scanning position of the electron beam based on the basis of the
characteristic a contour of the dose distribution and a the
predetermined pattern drawing on the base material is carried out
10 is drawn based on the dose distribution.

130. (Currently Amended) The pattern drawing method
described in claim 129, wherein the characteristic contour of the
dose distribution is defined beforehand.

131. (Currently Amended) The pattern drawing method
described in claim 128, wherein the specific pattern ~~includes~~
further comprises a diffractive grating structure ~~and the pattern~~
~~for reducing surface reflection.~~

132. (Currently Amended) The pattern drawing method
described in claim 131, wherein at least one pitch portion of a
the diffractive grating structure is formed with a tilt on the
curved surface portion of the base material, and the reflection
5 reducing structure comprises concave and convex portions ~~for~~
~~reducing surface reflection are formed for~~ in the at least one
pitch portion.

Application No. 10/080,638
Amendment

Customer No. 01933

133. (Currently Amended) The pattern drawing method described in claim 132, wherein ~~the characteristic~~ a contour of ~~the a~~ dose distribution for the electron beam is ~~extracted in accordance with~~ based on an inclination angle of a slope on the curved surface.

134. (Currently Amended) The pattern drawing method described in claim 132, wherein the at least one pitch portion of ~~a diffractive grating~~ comprises a side wall portion ~~rising up on the base material~~ at an end ~~position~~ of the pitch portion and a slope portion ~~formed between~~ extending from the side wall portion to a neighboring side wall ~~portions~~ portion, and wherein the concave and convex portions are formed on the slope portion.

135. (Currently Amended) The pattern drawing method described in claim 132, wherein the concave and convex portions comprise ~~a large number of~~ tapered hole portions.

136. (Currently Amended) The pattern drawing method described in claim 135, wherein ~~pattern drawing is done so as to make~~ a ratio of ~~the~~ a combined area of the hole portions to the an area of the slope portion ~~to be~~ is a predetermined ratio.

Application No. 10/080,638
Amendment

Customer No. 01933

137. (Currently Amended) The pattern drawing method described in claim 131, wherein each of at least two pitch portions of the diffractive grating ~~comprise~~ comprises a side wall portion ~~rising up on the base material~~ at an end position of the pitch thereof and a slope portion ~~formed between~~ extending from the side wall portion to a neighboring side wall portions portion, and ~~a wherein the~~ reflection reducing structure is formed on the slope portion of said each of the at least two pitch portions so as to reduce reflection of a light beam entering the slope portion or emerging from the slope portion.

138. (Currently Amended) The pattern drawing method described in claim 131, ~~further comprising the steps of~~ conducting a pattern drawing for wherein the irradiation of the electron beam to the curved surface portion of the base material is controlled based on the basis of the a dose distribution for a scanning position of the electron beam at the time of forming to form at least one pitch of a diffractive grating with a tilt including an inclined portion on the curved surface portion of the base material, and ~~conducting a pattern drawing of to form~~ concave and convex portions ~~on the basis of the dose distribution for the concave and convex portion at the time of forming the concave and convex portions for reducing surface reflection for~~

Application No. 10/080,638
Amendment

Customer No. 01933

in the at least one pitch of the diffractive grating as the reflection reducing structure.

139. (Previously Presented) The pattern drawing method described in claim 128, wherein the reflection reducing structure comprises a plurality of concave and convex portions having a function of structural birefringence.

140. (Previously Presented) The pattern drawing method described in claim 128, wherein the reflection reducing structure comprises a plurality of hole portions.

141. (Currently Amended) The pattern drawing method described in claim 140, wherein each of the hole portions has a tapered shape becoming which becomes smaller as ~~being deeper~~ the hole portion extends deeper.

142. (Currently Amended) The pattern drawing method described in claim 140, wherein an opening diameter of the hole portions is ~~shaped in an order of sub-micron~~ less than one micron.

143. (Currently Amended) The pattern drawing method described in claim 128, wherein the reflection reducing structure

Application No. 10/080,638
Amendment

Customer No. 01933

~~has a structure to reduce the~~ reduces reflection of a light beam
being incident on or outgoing from the reflection reducing
structure.

144. (Currently Amended) ~~The~~ A pattern drawing method
described in claim 123, of forming a predetermined pattern on a
layer of a base material, said method comprising:

irradiating an electron beam onto the pattern-drawn layer to
5 draw the predetermined pattern;

wherein the layer comprises a curved surface on which the
predetermined pattern is drawn;

wherein the predetermined pattern corresponds to a specific
pattern for an optical element; and

10 wherein the specific pattern ~~includes~~ comprises a polarized
light splitting structure.

145. (Currently Amended) The pattern drawing method
described in claim 144, wherein the polarized light splitting
structure ~~has a nearly~~ comprises a plurality of concave portions
and convex ~~shape~~ portions in a cross-section and has ~~an~~
~~approximately~~ a substantially circular shape in a plan view.

146. (Currently Amended) The pattern drawing method
described in claim 145, wherein ~~in the polarized light~~

Application No. 10/080,638
Amendment

Customer No. 01933

~~splitting structure, the plurality of convex portions comprise a~~
~~plurality of sets of~~ a first convex portion having a first width
5 and a second convex portion having a second width different from
the first width ~~are formed plural sets~~ with an interval between
the first convex portion and the second convex portion.

147. (Currently Amended) The pattern drawing method
described in claim 145, wherein ~~, in the polarized light~~
~~splitting structure, the plurality of concave portions and the~~
~~plurality of convex portions comprise:~~

5 a first convex portion having a first width;
a first concave and convex portion having a second width
different from the first width; and

a second concave portion ~~are formed alternatively, and~~
wherein ~~a first convex portion having a first width and a first~~
10 ~~concave portion having a second width different from the first~~
~~width are alternately formed in the first concave and convex~~
~~portion and the second concave portion has~~ having a third width
different from the first width and the second width; and

wherein the first convex portion and the first concave
15 portion are adjacent, and the second concave portion is adjacent
to the adjacent first convex and first concave portions.

Application No. 10/080,638
Amendment

Customer No. 01933

148. (Currently Amended) The pattern drawing method described in claim 144, wherein the polarized light splitting structure ~~has such a structure as to split an~~ splits a light beam incident ~~thereto~~ or outgoing ~~light beam therefrom~~ into at least two polarized light components oscillating in directions perpendicular to each other ~~on~~ in a plane crossing a ~~proceeding~~ traveling direction of the light beam.

149. (Currently Amended) The pattern drawing method described in claim 144, wherein the polarized light splitting structure ~~has such a structure as to split~~ splits a parallel light flux into a plurality of light fluxes composed of P polarized light and S polarized light having optical paths close to each other ~~respectively~~.

150. (Currently Amended) ~~The~~ A pattern drawing method described in claim 123, of forming a predetermined pattern on a layer of a base material, said method comprising:

irradiating an electron beam onto the pattern-drawn layer to draw the predetermined pattern;

wherein the layer comprises a curved surface on which the predetermined pattern is drawn;

wherein the predetermined pattern corresponds to a specific pattern for an optical element; and

Application No. 10/080,638
Amendment

Customer No. 01933

10 wherein the specific pattern ~~includes~~ comprises a birefringence phase structure.

151. (Currently Amended) The pattern drawing method described in claim 150, wherein the birefringence phase structure ~~has a~~ comprises a plurality of concave portions and convex shape portions in a cross-section and ~~an approximately~~ a substantially circular shape in a plan view.

152. (Currently Amended) The pattern drawing method described in claim 151, wherein ~~in the birefringence phase structure, a~~ the plurality of concave portions and convex portions comprises alternately formed convex portion portions having a first width and ~~a concave portion portions~~ having a second width shorter than the first width ~~are alternately formed~~.

153. (Currently Amended) The pattern drawing method described in claim 150, wherein the birefringence phase structure ~~is such a structure that produces a phase difference between one linearly polarized light flux and the other linearly polarized light flux among~~ incident or outgoing linearly polarized light fluxes oscillating in directions perpendicular to each other respectively.

Application No. 10/080,638
Amendment

Customer No. 01933

154. (Currently Amended) The pattern drawing method described in claim 150, wherein the birefringence phase structure ~~is such a structure that~~ produces a phase difference between light fluxes comprising at least a P polarized light flux and a S polarized light flux ~~among a plurality of light fluxes.~~

Claims 155-170 (Canceled).